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APOGEE ACOUSTICS

CENTAUR MINOR LOUDSPEAKER

Robert Harley

Floorstanding dynamic/ribbon hybrid loudspeaker. Driver complement: one 6.5" polypropylene-cone woofer, one 26"-long Apogee ribbon. Crossover frequency: 8001-hz, with second-order slopes. Frequency range: 40Hz-20kHz (no tolerance given). Impedance: 5 ohms. Dimensions: 13 1/2" W by 39" H by 9" D (stands add 8" to height). Weight: 128 lbs/pair, shipping (stands are 22 lbs/pair shipping). Price: \$1195/pair, stands are an additional \$149/pair. Warranty: 3 years, limited. Approximate number of dealers: 95. Manufacturer: Apogee Acoustics, 35 York Industrial Park, Randolph, MA 02368. Tel: (617) 963-0124. Fax: (617) 963-8567.

It is gratifying for a high-end audio reviewer to audition the very best components technology can offer—without regard for cost. The value judgments made of such products are much easier to formulate; the reproduced sound is judged on an absolute basis rather than with a value-for-money approach. The reviewer's job is more to describe the sound of the component, not determine how much money it is worth. Although the reviewer may not be able to afford these cost-no-object components, he can still make a recommendation to those who can.

Enjoyable as it is to spend months auditioning the ultra-high-end gear, I find another aspect of reviewing even more rewarding: discovering a product that offers far more musical satisfaction than its modest price would indicate. This is especially true when the product is a runaway performer and its cost is within the reach of almost any music lover. Indeed, such components are often priced no higher than many poor or mediocre mid-fi products. Finding such a bargain and spreading the word gives the reviewer the satisfaction of knowing that many music lovers will enjoy far better sound because of his efforts.

On to the \$1195 Apogee Centaur Minor loudspeaker. I heard this ribbon/dynamic hybrid at its CES introduction and was surprised that such an inexpensive loudspeaker could produce such a high-end sound. A few months later at the Taiwan High-End Hi-Fi Show, the Minor's superb sound cried out for a full audition and review. As I sat there listening, my first thought was that products with this level of performance and low price should be trumpeted—provided they performed as well under extended auditioning. As soon as I returned from Taiwan, I called Apogee's Jason Bloom and asked for a review sample. He personally delivered and set up a pair of Centaur Minors in my listening room for this evaluation.

As you might have guessed, this introduc-

tion about finding reasonably priced but overachieving high-end components applies to the Centaur Minor—in spades. After spending the past month listening to them, I am convinced that they are not only the greatest value in moderately priced loudspeakers today, but also one of the best buys in all of high-end audio.

But you'll have to read the full review to find out *why* I think the Centaur Minor is such a bargain—and also why they are *not* for everyone.

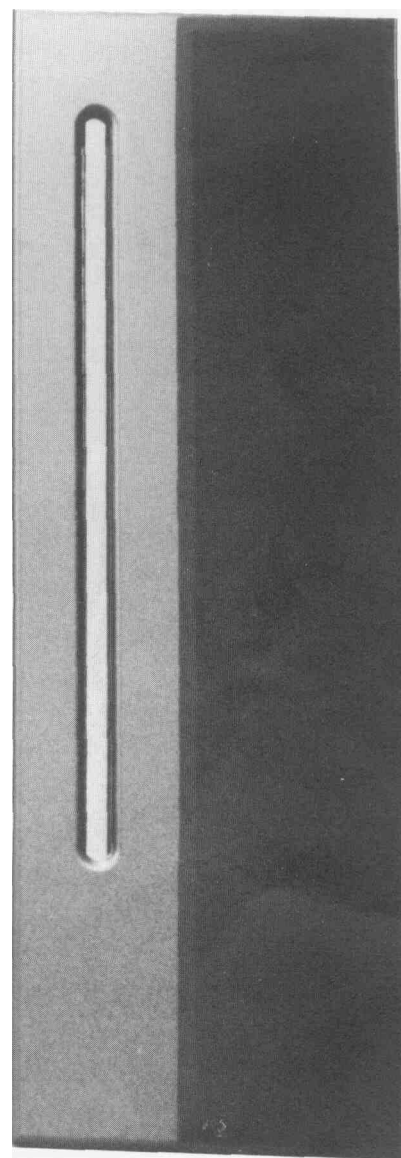
TECHNICAL DESCRIPTION

The Minor's distinctive appearance immediately establishes it as not just another me-too box loudspeaker. The 9y2"-wide, 38"-high Minor is basically a flat panel with a narrow box attached to the rear. This unique configuration is dictated by the Minor's unusual driver complement: a 26"-long midrange/tweeter ribbon runs vertically along the flat panel's inside edge, and a 6V2" woofer is mounted in the box. A black cloth grille that cannot be removed covers the panel from top to bottom and extends about two-thirds of its width. The Minors are shipped in mirror-imaged pairs.

A recessed **rectangle on the woofer** enclosure's rear panel hold a pair of five-way binding posts and a three-position switch marked Low, Normal, and High. This switch attenuates the woofer's output level in 1.5dB increments, helping to match the Minor to the user's room. The front panel is finished in a handsome charcoal-grey textured veneer.

Apogee offers matching stands for the Minor ((149/pair) that raise the loudspeaker 8" off the floor. The stand's top panel is removable for filling with sand or lead shot. Because the stand's footprint is identical to the Minor's, it seems like a logical extension of the loudspeaker.

Four carpet-piercing spikes are supplied with each Minor. If the stands are used, the spikes thread into the stands; four additional



Apogee Centaur Minor loudspeaker

blunt spikes then thread into the loudspeaker, which rests on the stand. If this sounds awkward, it's not; the stand's top edge has holes drilled to accept the blunt spikes. These holes are covered by the veneer and become visible only after breaking the veneer with the blunt spikes. The pair of spikes at the loudspeaker rear rest on the stand top, and can be threaded at varying depths to adjust the Minor's rake angle.

Overall, the Minors and stands look beautiful; they're tall, dark, and handsome. **In**

addition, the stands appear to be almost an integral part of the loudspeaker rather than an afterthought.

The Centaur Minor is, to my knowledge, the least expensive loudspeaker ever offered that uses a ribbon driver (apart from the \$1000 Magnepan .1/QR introduced at the June 1991 CES). Despite its low price, the Minor's ribbon is identical to that used in Apogee's \$2395 Stage. Since DO's enthusiastic review in August 1990, the Stage has become a reference at its price range.

The advantages of ribbons have been available previously only at much higher prices. The trick to making a ribbon speaker so affordable was the decision to design a hybrid, mating a conventional moving-coil bass driver to the ribbon. This is a notoriously difficult challenge; the moving-coil driver, which is omnidirectional at low frequencies and more like a cardioid in the midrange, and the dipole ribbon have very different dispersion characteristics. Getting the two drivers to integrate is not easy, therefore. The ribbon's dipole radiation pattern and low impedance have limited its use in all but esoteric systems. In addition, the ribbon's dipole nature makes placement more critical than conventional box loudspeakers—giving it less mass-market appeal. The Centaur Minor seems to have successfully solved most of these problems. The result is a ribbon-based loudspeaker affordable by Everyman.

Let's take a closer look at how a ribbon works. A ribbon driver is an electromagnetic transducer just like a conventional moving-coil driver. Diaphragm motion is created by electromagnetic interaction between fixed magnets and a magnetic field created by the audio signal. But instead of having the audio signal conductor wound into a coil attached to a cone (or dome), the conductors are flat and imbedded in the diaphragm—usually a thin strip of aluminum foil. This strip is suspended between two very powerful magnets. The constantly varying magnetic field created by current flow through the ribbon's conductors reacts with the permanent magnetic field, moving the ribbon back and forth.

A primary advantage of a ribbon is its low mass. Without a cone, voice coil, former, or spider, a ribbon can react more quickly to the applied electrical signal. Further, it has much less potential for storing mechanical energy for release after the input signal has stopped or changed. The problems sometimes associated with moving-coil drivers—blurring, overhang, and transientsmearing—are largely avoided in ribbon transducers. Ribbon microphones have long been valued for their transient qualities and openness.¹

The Minor's midrange/tweeter ribbon is a thin strip of Kapton-backed composite material suspended in a very strong magnetic field. (Don't bring ferrous materials—or a wristwatch—near the Minor; the magnetic field is that powerful.) The ribbon is sup-

ported at the top and bottom of the structure, hanging between a pair of high-energy strontium ferrite ceramic magnets that run the length of the ribbon. Unlike previous designs, the ribbon is not supported at points along its length. This technique of removing diffraction-causing braces was pioneered during conceptual development of Apogee's \$65,000 Grand loudspeaker. Unusually, no impedance-matching transformer is used; a ribbon's normally very low intrinsic impedance (less than 1 ohm) typically requires a transformer to present a higher impedance to the amplifier.

A 6¹/₂" long-throw woofer sourced from Vifa is mounted in a sealed 0.6 ft³ enclosure. The woofer features a 1" voice-coil, mineral-filled polypropylene cone, and high-loss rubber surround. The front baffle is made from 1" A"-thick fiberboard, and the woofer enclosure is W"-thick (sides) and 1"-thick (rear panel) MDF. All front-facing panel edges—including the ribbon slot—are gently rounded to optimize diffraction effects. The Minor has an unusual and beautiful thermally bonded dark charcoal finish.

Second-order slopes (12dB/octave) are used in both the high-pass and low-pass filter sections, with a crossover point of 500Hz—the same as the Stage. Air-core inductors and polypropylene capacitors are employed throughout. All internal wiring is point-to-point with solid-core oxygen-free copper—no circuit board is used for holding crossover components. Impedance is rated at 5 ohms.

Construction quality and fit'n'finish are superb. The speakers have an elegance and level of finish one might find in a product costing much more.

SETUP

The Centaur Minors took center stage in my listening room for the past four weeks (I also spent some time with them just after they were set up). As indicated previously, Apogee's Jason Bloom set them up, tweaking their position in the room for best sound. Jason's skill in system setup is highly regarded, his displays at shows being consistently musical and often voted "Best Sound of the Show." It was an interesting experience to spend the day with him, repeating the move/listen cycle. With less than an hour of tweaking their position, Jason was delighted with the way the Minors sounded. I marked their location with tape on the carpet.

The speakers ended up with the front baffle's center 48" from the rear wall. One loudspeaker was 48" from the side wall, the other 44". They were toed-in so that there was a 3¹/₄" distance differential from the back wall to the front baffle's left and right edges. The listening position was 11' from a point midway between the Minors.

During setup, I noticed that very slight changes in position had large effects on the sound. When Jason moved each of the Minors an inch closer together, the soundstage snapped into focus. Moving them forward in the room changed their presentation of depth from good to stunning. Further toe-in had a huge effect on both tonal balance and soundstaging.

In addition to room placement, the Minor's rake angle had a dramatic effect on the presentation. The Minor's degree of rearward tilt is determined by how far in the two rear spikes are threaded. It was thus very easy to adjust the rake angle: tilt the speaker forward and give each spike a turn or two. Again using the rear wall as a reference, the top of the baffle was P/s" closer to the rear wall than the baffle bottom. The ear's resolution in hearing differences in rake angle, however, was far better than a tape measure. This rake angle may be a good starting point, but final tweaking must be done by ear. Further, the optimum rake angle will change with listening height. (My chair places my ears 36" above the floor.)

Incidentally, the Minors sounded better with absorbing material behind them. My listening room has a window on the loudspeaker wall covered by heavy drapes. The Minors' soundstaging improved with the drapes drawn.

In addition, all these parameters—position, toe-in, rake angle, listening distance—are interactive. Without Jason's expertise, I could have spent several days of trial and error before achieving the musical presentation I'm about to describe.

MUSIC

Associated components included the VTL 225W Deluxe Monoblock power amplifiers, Audio Research LS2 line stage, Vendetta Research phono preamp, Audio Research DAC1-20 D/A converter, and a Theta Data CD transport. LP playback was provided by a Well-Tempered Turntable and LP Lab-modified arm, fitted with an AudioQuest 7000 cartridge. I also spent considerable time with the Linn CD player (reviewed this issue) as the digital front end. Interconnects were AudioQuest Diamond (the phono signal path) and Straight Wire Maestro (CD to preamp and preamp to power amps). Loudspeaker cable was a pair of 10' runs of Symo, the cable Apogee recommends for all their loudspeakers. (DO also found the Symo to work best with the Stages.) Also on hand was the solid-state Jeff Rowland Model 1 power amplifier. The dedicated listening room has optimum dimensional ratios for room-mode distribution. A pair of Phantom Acoustic Shadows, an active low-frequency control system, was turned off during the auditioning. The turntable was mounted on a lead-shot-filled Merrill Stable Table. AC power to the system (except the VTLs) was conditioned by a Tice Power Block and Titan.

I'll start by saying that the Centaur Minor is a stunning product for \$1195. It does some things as well as any loudspeaker I've auditioned in my listening room. More important, the Minor's overall presentation and musicality were superb by any measure.

First, I was taken by the Minors' transparency and ability to throw a huge, three-dimensional soundstage. Not only did the loudspeakers disappear, the entire back third of the listening room vanished. The room's walls were replaced by the recorded acoustic, with the listening room's size changing with

¹ For a technical discussion of ribbon loudspeakers, see my interview with Celestion's Graham Bank in Vol.13 No.5 (May 1990).

each recording. The soundstage easily extended beyond the Minors' lateral boundaries. The Minors were clearly in another league when compared to similarly priced box loudspeakers. There were layers and layers of musical detail between the listener and the soundstage rear. Instruments were clearly behind one another, yet not in an obscuring way. This ability to resolve three-dimensional layering was extraordinary. Moreover, the amount of depth varied with the recording, putting the listener in the correct acoustic environment and enhancing the feeling of spatial realism.

Adding to the three-dimensionality was the Minors' ability to separate disparate musical lines. Instruments didn't sound fused together and synthetic—they floated in space, each with an independent identity. The *Three-Way Mirror* CD (Reference Recordings RR-24CD) was particularly impressive. This recording's sense of instruments existing within a reverberant room was superbly conveyed by the Minor. Listen to the sheer sense of depth on the first track as the percussion and fretless acoustic bass slowly emerge from the ambience. On the next track, the steep attack of the drums in the drum solo seems to "light up" the surrounding acoustic space. This is analogous to a flash of light in a dark room that suddenly illuminates the walls and their distance.² On the Dorian CD *The English Lute Song* (Dorian DOR-90109), the voice and lute were bathed in the gorgeous acoustic of the Troy Savings Bank Music Hall. In addition, the reverberation wasn't just tacked on to the voice and lute images. Instead, there was a clear sense of distance between the performers and the hall reflections. The impression of instruments existing within an acoustic space was nothing short of stunning.

These examples illustrate the Minor's special abilities in revealing spatial cues. Provided the loudspeaker does other things well, this resolution of the recorded acoustic is important to the musical experience. It transports the listener to the musical event and presents a much more convincing illusion of reality than one in which the music is confined to the listening room and squashed between the loudspeakers.

One aspect of the Minor's soundstaging I found engaging was a slight blurring of instrumental outlines. Instead of throwing sharply defined images, outlines were slightly diffuse around the edges. I grew to prefer the naturalness of this presentation. On one of my own acoustic jazz recordings there was a surprising sense of palpability and presence, conveyed in part by this realistic reproduction of instrumental images. Conte Candoli's flugelhorn had a roundness and halo of air around it that were very similar to my memory of the live sound.

Another aspect of the Minor's performance that set it apart from run-of-the-mill box loudspeakers was its midrange purity and transparency. There was a complete absence of boxiness, congestion, or haze.

Vocal and instrumental timbres were remarkably lifelike and pure. In addition to uncolored timbres, there was also an impression of the instrument being *right there* in the room. The sense of veiling and accompanying detachment from the music so often heard was notably absent. Instead, the Minors provided a clear picture window on the music. The new Chesky CD of Kenny Rankin (CheskyJD63) was a good example. This is a stunning recording, and the Minors were up to the task. The vocal seemed suspended in space between the loudspeakers with no clue that the sound was being mechanically reproduced. This transparency worked synergistically with the soundstage depth to create a huge, see-through soundscape before the listener. Overall, the Minor's midband neutrality, openness, transparency, and sense of realism was among the best I've heard—regardless of price.

The tonal balance was a little lightweight, but exceptionally smooth and refined. The treble struck the perfect balance between smoothness and detail. High-frequency transients weren't etched or hyped, yet there was a full measure of HF detail and life. Treble textures had a notable lack of edge, especially on instruments—like the violin—so often colored by loudspeakers. Listen to Stephane Grappelli on the live album with David Grisman (Warner Brothers BSK 3550). The steely top end that makes a violin sound screechy was replaced with a smoothness that was so much closer to what a violin actually sounds like. This impression was repeated with a number of violin recordings, jazz and classical. (Coincidentally, I made a violin recording during this review.) Similarly, cymbals didn't have the spitty component that makes music listening fatiguing. There was a sense of ease, yet at the same time a vibrant quality. Horns were rendered with a natural burnished brass quality rather than an artificial chrome-plated appearance.

The Minors were superb in portraying "fast" instruments like percussion and acoustic guitar. These instruments' transient attacks were razor-sharp and well-defined, yet lacked an unnatural edge. So many loudspeakers try to make up for lack of speed by etching transients. Rather than force detail on the listener, the Minor presented many layers of inner detail that invited the listener into the music. I very much enjoyed this refined and subtle presentation. It was refreshing to hear tons of fine detail without the hype.

The bass seemed to integrate very well with the mids and treble; there was not the feeling of listening to two different sources. I found, however, the low end slightly lean and overdamped, making the presentation a bit on the thin side. This presentation, however, is far preferable to a bloated, underdamped alignment that plods along. Pitch definition was moderately good, but the bass lacked the warmth, precision, and textural liquidity found in some other comparably priced loudspeakers. There was a slight wooliness that could tend to obscure pitch. The slightly lightweight character didn't convey as great a sense of warmth as I would have

liked. Acoustic and electric bass were less full than through my reference Hales System Two Signatures. There wasn't as great a sense of bloom surrounding these instruments as I would have liked.

In addition, the upper bass had a kind of boxiness and hooded character on some recordings. This region could sound colored, especially on left-hand piano lines. The piano on one of my own jazz recordings, for example, had a sometimes unnatural, closed-in character in the lower registers. This signature wasn't always apparent; it was heard more on some recordings than others. Importantly, it didn't seem to affect other instruments like voice, sax, and guitar.

Bass extension was **moderate, but not** exceptional. Although I got a good feeling of weight, the Minor lacked the ability to deliver lots of punch in the lowermost octaves. The drums on *James Newton Howard and Friends* (Sheffield Lab 23), for example, didn't convey the power and depth of the instrument, especially the floor tom and kick drum. Generally, I preferred the bass presentation of the Monitor Audio Studio 20s reviewed last month. It should be added, however, that the Studio 20s cost nearly four times as much as the Minor.

My other criticism was that the Minors didn't always convey the punch and dynamics of some music—especially rock and fusion. The snap and punch of snare drum, the kick of bass drum, and the power of toms were slightly muted compared to some other loudspeakers auditioned. The Minor was better suited to jazz, classical (both small- and large-scale), and choral music than to hard-driving rock.

That said, there are a few points I'd like to make. First, there is a tendency to be overly critical of some aspects of a product when it is an overachiever in other areas. The best attributes tend to serve as the reference for all other characteristics. Consequently, the criticism can become harsher than if the loudspeaker performed poorly in other areas. This should be kept in mind when reading the above criticisms—the bass performance was good, but not up to the high standards set by the rest of the system.

Second, what really matters is the total musical experience, not some specific aspect of it. In this regard, I have nothing but praise for the Minor. Its ability to involve the listener in the music was extraordinary. When listening to music through the Minors, I forgot about reviewing, tending to discard the usual diagnostic source material in favor of musical favorites. I would play entire records, enjoying the music and being uncritical of the Minors' flaws. After three weeks of auditioning I found myself with no listening notes; only during the last week of auditioning did I bring out the notepad and look for shortcomings. Very few loudspeakers I've auditioned in my room have produced a comparable level of musicality.

How can such an inexpensive loudspeaker provide a musical experience that, in my opinion, far exceeds any available at the price? After some thought, I came to the conclu-

2JA devised this appropriate analogy.

sion that the Minors' compromises—compromises necessary in a \$1200 loudspeaker—were carefully adjusted to be of the least musical significance. Conversely, the areas with the greatest effect on the overall musical experience—midrange and treble purity, transparency, soundstaging—were maximized. As a result, it was very easy to ignore the compromises and enjoy the music.

For example, I had just gotten the new Kenny Rankin CD on Chesky. My wife and I went in the listening room to hear one or two tracks—other business pressed. We ended up not only listening to the entire CD, but spent the next three and a half hours pulling out old favorites and new additions to the music collection. During the entire listening session, I heard the music and not the loudspeakers. This is the surest sign that a product is fundamentally right.

I'll conclude with a few comments on the woofer-level switch, stands, and using the Minor with a subwoofer. Although I found the woofer switch's Normal position best, I could hear how it would improve the Minor's interaction with other listening rooms. The colorations I heard in the bass were mitigated with the switch in the Low position, but this also made the presentation thinner and less satisfying. The High position gave more weight to the music, but also made me more conscious I was listening to loudspeakers. The stands should be considered mandatory. In addition to making the Minor more stable physically, I found the imaging and tonal balance improved when the speakers were lifted up and supported by the heavy base. Further, adjusting the rake angle is far easier and more precise with the stands. Not only that, but the Minors look more attractive.

At the end of the auditioning, I ran the Minors with the Muse Model 18 subwoofer, using a 100Hz crossover card in the Muse. The results were impressive. I got the extension, depth, and power of the Muse *and* the transparency, openness, and soundstaging of the Minors. There was still a little of the bass coloration noted with the Minors by themselves, but the overall presentation was terrific. You can add the Minor to the long list of loudspeakers with which the Muse Model 18 works well. Incidentally, the Minors loved the VTLs—the sound was lush and gorgeous.

Finally, I cannot overstate the case for careful setup and use of notch electronics with the Minors. Very small changes in positioning have a huge effect on the sound. It is possible to move each loudspeaker *an inch* and destroy the Minor's special qualities. Changing the rake angle or listening height a few degrees transforms the presentation from mediocre to superb.

I can very easily imagine someone reading this rave review, auditioning the Minors in a store, and emerging unimpressed. The kind of presentation I've described is possible, but the listener must be prepared to devote significant work to realize the Minor's potential. Your efforts will be well rewarded. I must also advise those planning to spend much more on loudspeakers to audition the

Minor. Even if you have several thousand dollars budgeted, don't dismiss the Minor because of its low price. It compares favorably to much more expensive systems and, in some areas, easily outperforms them.

MEASUREMENTS

The Minor's impedance and phase angle are shown in fig.1. The curves are, from top to bottom, with the woofer contour switch set in High, Normal, and Low positions. Note the impedance peaks at the woofer tuning (57Hz) and near the crossover. The minimum impedance was 3.6 ohms at 2.5kHz. Overall, the impedance is lowish, but not low enough to cause problems for most high-quality amplifiers. In addition, the impedance is fairly constant with frequency with no severe impedance dips. The phase angle is also relatively benign.

Looking at the impulse response (fig.2), the ribbon and woofer appear to be wired in the same polarity. There is a slight ringing after the impulse, but it decays quickly. Taking five impulse responses over a 30° lateral window, transforming them from the time domain to the frequency domain, and averaging the resultant amplitude responses yielded the curve to the right of fig.3. We can see that the top octave is slightly depressed, rolling off above 10kHz. Despite this roll-off, I never felt a loss of air or extension during

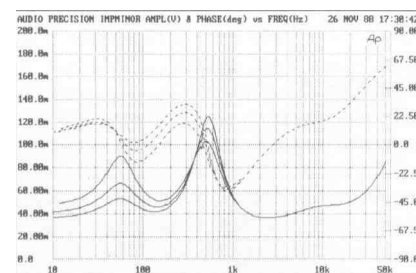


Fig.1 Apogee Centaur Minor, electrical impedance (solid) and phase (dashed) (2 ohms/vertical div.). Woofer contour switch set to High, Normal, and Low.

Fig.2 Apogee Centaur Minor, impulse response on listening axis at 45° (5ms time window, 30kHz bandwidth)

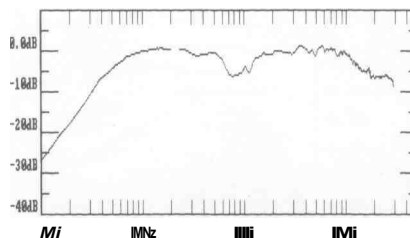


Fig.3 Apogee Centaur Minor, anechoic response on listening axis at 45° averaged across 30° horizontal window and corrected for microphone response, with nearfield bass response below 200Hz.

the auditioning. In fact, I found the timbre and texture of high-frequency-rich instruments to be more natural than many loudspeakers. The Minor is remarkably flat through the region between 1.5kHz and 10kHz. Amplitude anomalies are very audible in this region; not only does much of the music lie in this area, but the ear has far greater sensitivity to amplitude variations between 1kHz and 4kHz than in other frequency bands. The Minor's midrange purity, openness, and transparency may be partially attributable to the smooth response in this band.

The other prominent feature of fig.3 is the fairly large suckout at the crossover region. Although this dip is present in the on-axis response (not shown), it is very severe in the woofer side off-axis response but less significant on the ribbon-side off-axis response. By averaging the response over a 30° lateral window, the huge interference suckout off the woofer axis makes a large contribution to the curve of fig.5 (each position is equally weighted in the averaging). Because the listener sits slightly off the ribbon axis, however, the dip is probably less deep at the

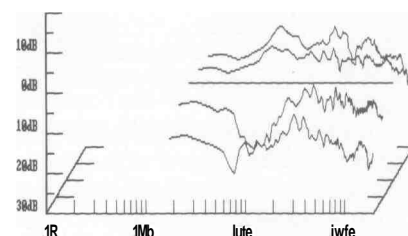


Fig.4 Apogee Centaur Minor, horizontal response family at 44°, normalized to response on ribbon axis, from back to front: difference in response 15° off-axis on ribbon side; difference 7.5° off-axis on ribbon side; reference response; difference 7.5° off-axis on woofer side; difference 15° off-axis on woofer side.

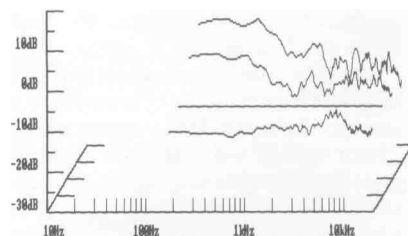


Fig.5 Apogee Centaur Minor, vertical response family at 44°, normalized to response on ribbon axis, from back to front: difference in response at top of the panel; at top of ribbon; reference response; 8° up from bottom of ribbon.

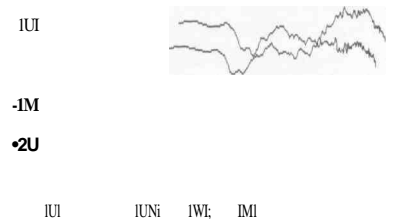


Fig.6 Apogee Centaur Minor, effect of rake angle: from back to front: response with ribbon vertical; response with ribbon at normal rake angle.

listening position than the curve would indicate.

Fig.3 also reveals that the Minor's low-frequency -3dB point was 59Hz (the woofer tuning frequency), and the -6dB point was 43Hz. This is indicative of a slightly overdamped alignment, which I have found to be sonically preferable to an underdamped alignment.

The set of curves in fig.4 shows the differences in response at various positions horizontally off-axis. The top two curves are at 15° and 75° off-axis on the ribbon side, the middle curve is the reference, and the bottom two curves are at 7.5° and 15° off-axis on the woofer side. Note that these are the *difference* curves between the on-axis and off-axis responses, not the actual responses. This series of measurements, which assumes the on-axis response to be perfectly flat, reveals the loudspeaker's dispersion characteristics which create differences in the off-axis tonal balance. The smoothest response is 7.5° off the ribbon axis—coinciding exactly with the listening axis when the Minors are slightly toed-in. The listening axis suggested by fig.4 is identical to the listening axis suggested by ear. Note the large interference suckout between the drivers at the crossover point (800Hz) when the listener is off-axis on the woofer side. This dip is filled in off the ribbon axis, but is accompanied by a greater treble roll-off.

The Minor's vertical response family (fig.5) shows a similarly large shift in response as the measurement microphone is moved away from the optimum listening axis. The bottom curve was taken 8" up from the bottom of the ribbon, the flat line is the on-axis reference, the next curve up was taken at the ribbon top, and the uppermost curve was generated with the measurement microphone at the top of the panel. Again, note that these curves are the differences in relation to the on-axis response, not the responses themselves. These curves indicate that listening height is critical; don't audition the Minors while standing up!

Since the Minor's rake angle had such a large effect on the sense of immediacy and presence, I measured the response with the Minor vertical and at the rake angle suggested by the auditioning (fig.6—unlike figs.4 and 5, these are the actual measured responses, not the differences). The top curve is with the loudspeaker vertical, the bottom at the normal rake angle. Notice the large increase in energy over a wide band in the mid-treble when the Minor is vertical. This correlates to the significant change in the sense of immediacy I heard when adjusting the rake angle.

These last three sets of measurements confirm my experiences during the auditioning—placement, toe-in, rake angle, and listening height are all significant variables in the presentation the listener hears. It cannot be stressed too strongly that potential purchasers should be aware of these variables and be prepared to balance them to achieve the level of musical presentation described earlier. Don't be afraid to experiment.

The Minor's cumulative spectral decay, or

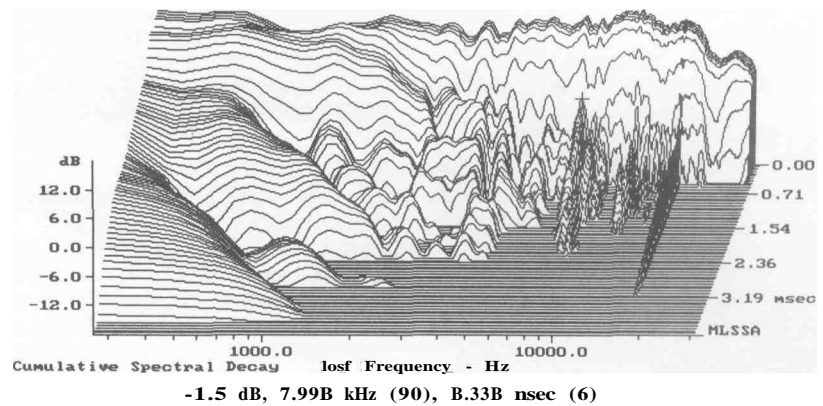


Fig.7 Apogee Centaur Minor, cumulative spectral-decay plot

"waterfall" plot (fig.7), shows a clean decay in the treble, apart from a minor resonance at 8kHz. The quickness of the treble decay is not surprising for a low-mass transducer like a ribbon. Note that the dark ridge at around 16kHz (actually 15.750kHz) is the computer monitor's scanning frequency and not part of the loudspeaker behavior.

When I drove the Minor with a variable-frequency sine wave oscillator to look for cabinet resonances, I found the enclosure to be fairly lively despite the 1" -thick rear panel and 1A" front baffle. Specifically, there were cabinet vibrations accompanied by changes in tone at 85Hz, 110Hz, and 170Hz. The cabinet was fairly inert until 430Hz, when there was a loud howl that obscured the sound of the sine wave. To examine this behavior in more detail, I used the trick invented by JA in his Icon Parsec review a year ago: place the two loudspeakers touching face to face, invert polarity on one, drive them with MLSSA's Maximum Length Sequence (MLS) signal, and take the impulse response of the cabinet with the measurement microphone almost touching the enclosure panel. The acoustic output from the out-of-phase drivers largely cancels (except through the top octaves), leaving only the cabinet's acoustic output. The lack of high-frequency cancellation is inconsequential when a narrow measurement bandwidth

(in this case, 1kHz) is used.

When I drove the Minors in this way, there was a clearly audible pitch to the sound being produced by the cabinet. Beneath the pink noise-like MLS signal, there was a tone with a specific frequency; it sounded suspiciously close to 400Hz. Fig.8 is the impulse response of the rear panel taken under the conditions described. The ringing is clearly apparent long after the exciting impulse. Counting the number of cycles over a 20ms period (8) and multiplying by the period of a 430Hz wave (2.4ms) confirmed that the ringing was indeed at 430Hz.

Creating a waterfall plot from the cabinet's impulse response confirmed the diagnosis. A waterfall plot is produced by performing a series of Fast Fourier Transforms on the impulse response at discrete time intervals. This technique is useful for examining frequency-domain effects over time—in other words, resonances. This plot is shown



Fig.8 Apogee Centaur Minor, nearfield impulse response of rear panel's acoustic output (100ms time window, 1 kHz bandwidth)

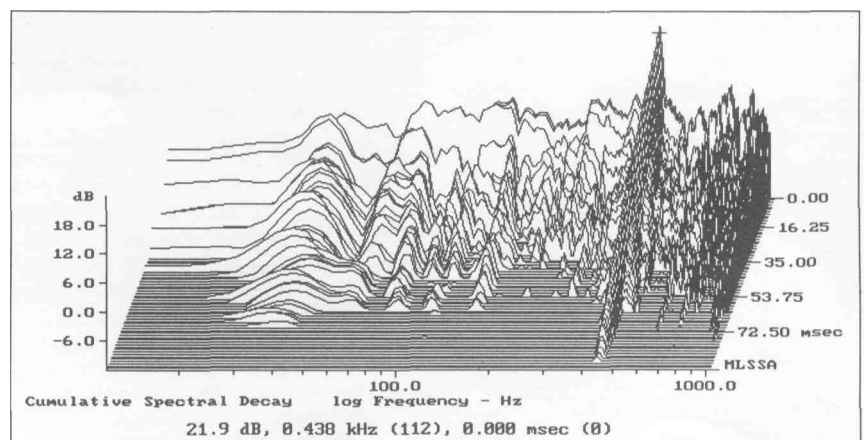


Fig.9 Apogee Centaur Minor, cumulative spectral-decay plot of rear panel's acoustic output

in fig.9. The severe resonance at 438Hz is clearly apparent as the large spike at the top of the plot. The accompanying vertical ridge is the resonance slowly decaying over time. The other resonance modes I detected with the oscillator are also apparent, seen as ridges at 170Hz, 110Hz, and 85Hz. The woofer resonance can also be seen as the wide ridge toward the left-hand side of the plot. The 438Hz resonance may be partly responsible for the boxiness and coloration I heard on left-hand piano lines on some recordings. The resonance, however, is very high "Q" (narrow bandwidth) and is not likely to be excited frequently.³

Overall, the measurements correlate very closely to the auditioning impressions: smooth midrange and treble, lack of low bass extension, and a tonal balance greatly influenced by listener position, rake angle, and loudspeaker position.

³ A useful rule-of-thumb in looking at resonances is to assume that their Q or "quality factor" equates with the number of sine wave cycles it takes to fully excite them. A resonance at 1kHz with a Q of 1000—a very high, narrow-width-frequency peak like the one in fig.9—will therefore need to be stimulated for fully one second with 1kHz for it to be excited fully. If its Q were just 2, however, while the amplitude peak will not be nearly as high as if the Q were 1000, it will only take 1/500 second to be fully excited, and two cycles of 1kHz are much more likely to occur in music than 1000. And low-Q resonances have indeed been found to be generally more audible than high-Q ones. —JA

CONCLUSION

Properly set up and driven by topnotch electronics and source components, the Apogee Centaur Minor produced the kind of musical presentation I wouldn't have thought possible from a (1200/pair of) loudspeakers. In fact, some aspects of its performance were world-class. The Minor's sheer transparency, textural purity in the mids and treble, and spectacular soundstaging were among the best I've heard in my listening room. Their ability to throw a wide, transparent soundstage with layer upon layer of depth was extraordinary by *any* standard. Further, the Minor's transparency and lack of boxiness in the mids and treble are unprecedented at this price. In short, the Minor provided much more than a taste of high-end sound at a price that would put many more expensive systems to shame. Once you hear the seamless transparency of the ribbon, it may be difficult to go back to listening to cone and dome drivers.

The Minor did have some problems, however. While the overall balance was musically satisfying, some listeners may prefer greater extension and power in the bass. In this regard, other comparably priced systems—the Vandersteen 2Ci, for example—will outperform the Minor. In addition, I found the texture and quality of the bass below the performance of the mids and treble. Specifically,

the mid and upper bass tended to be slightly boxy and colored on some recordings. Finally, the Minor was better suited to revealing subtlety and nuance than cranking out high-level rock'n'roll.

What makes me Minor so special, however, is that these flaws and compromises were overwhelmed by the speaker's overall musicality. Some loudspeakers' shortcomings are constantly and painfully evident, making it hard for the listener to forget the playback system. When listening to music through the Minors, it was *easy* to forget the loudspeakers. I had to *try* to listen critically and hear these deficiencies rather than being constantly hit over the head by them. Apogee has done a near-miraculous job of hiding the Minor's compromises beneath its considerable strengths. After all, what *really* matters is the total musical experience, not specific performance attributes.

If you're prepared to spend the effort or setup—and have a room conducive to proper placement—the Apogee Centaur Minor can provide truly high-end sound on a modest budget. (Those lacking either placement flexibility or the enthusiasm for spending days tweaking may be disappointed, however.)

If I had up to \$2000 to spend on loudspeakers tomorrow, the Apogee Centaur Minor would be my first choice. Recommendations don't come any higher than that. S